XL.—*On the Composition of Chalk Rocks and Chalk Marl by invisible Organic Bodies: from the Observations of Dr. Ehrenberg.* *By* THOMAS WEAVER, *Esq., F.R.S., F.G.S., M.R.I.A, &c. &c.*

[Concluded from p. 315.]

On the Composition of the Compact Limestone of Upper Egypt and Arabia by the invisible Animalcules of the White Chalk of Europe.

BOTH the nummulite limestone of the pyramids of Geza on the left bank of the Nile, and the same kind of rock on the right bank near Cairo, contain numerous microscopic animalcules of the chalk, which serve as a cement to the Nummulites. I had often examined microscopically specimens which I had brought from thence, but I did not succeed in separating and rendering visible the different elements with equal clearness, until I applied my newly-acquired practice, which was much facilitated by immersing these stones a longer time in water. The same result attended the examination of the other calcareous rock masses of Upper Egypt and Arabia, showing that the animalcules of the chalk occupy in a surprising manner a wide extent of country in Libya.

Nummulite limestone, wherever occurring, has been most usually referred to the tertiary period, although perhaps often belonging to the chalk. In Egypt it possesses no great extent. On the right bank of the Nile it is deposited only in the small hills near Cairo, and on the left bank, as it appears, in a tract extending from Siout to the declivity of the compact limestone, which latter constitutes the mass of the rocks that line the course of the Nile in Upper Egypt. It forms the foundation and principal material of the Pyramids. Northward it is directly bordered by the slimy delta of the Nile, the productive soil of Egypt. Between the Oasis of Jupiter Ammon and the Mediterranean, is a wide elevated plateau or tableland of rock, among whose numerous organic remains are known tertiary forms. The whole of Upper Egypt, as far as Syene, has a similar character. In 1828, though assured that its limestone rocks were more ancient than the tertiary period, yet, from want of distinct fossils, I was doubtful whether they might not be referred to the Jura formation. On the south, and not far from Syene, this limestone is incumbent on sandstone (Quadersandstein ?), and the two repose on granite and the primary rocks connected therewith. I gave these views in 1828 in the geologically coloured map which accompanied the first section of the first volume of my Travels in Egypt, Libya, Nubia, and Dongola.

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taken place, that the whole of the limestones of Benisuef, Siout and Thebes, on the western bank of the Nile, and of Cairo and Kineh (including the gray marl near Kineh), on the eastern bank, and which inclose the Nile at an elevation of frequently 100 to 300 feet above its level, extending along the river full sixty German miles in length, are, like the Nummulite limestone, composed of an inconceivable accumulation of microscopic calcareous-shelled animalcules, which are of precisely the same genera and species as those which constitute the chalk of Europe. The table-land formed by these calcareous rocks extends far westward into the Desert, and it is perhaps principally composed of them.

A new and unexpected light is thus thrown on these extensive regions. The phænomena apparent in Egypt may be connected with those of Western Africa. It has been already shown that the same animalcules constitute the territory of Oran, stretching far along the foot of the Atlas; and when we consider the equality of surface which prevails in the plain of the Great Desert, or Sahara, of the North of Africa, and compare it with what I have myself seen along the whole extent of its eastern border, as well as on a large portion of its northern, we may be well permitted to think of a similarity of composition.

But these distinct indications of a similar organic influence extend not merely to the west but also to the east of Cairo, expanded into Asia. The specimens collected by Dr. Hemprich and myself from Hamam Faraūn, and Tor in the Sinaian portion of Arabia, which I had formerly considered as ash-gray marl and yellowish-gray limestone of the tertiary epoch, were now proved, by the new method of examination, to consist of quite the same microscopic chalk animalcules as constitute the hilly masses of Upper Egypt. And from hence this formation appears to be continued eastward far into the interior of the Great Desert plain, trending toward Palestine; but on the Arabian coast of the Red Sea we did not find it further south than Tor, which locality alone, among all the points of the east, yielded flints similar to those which occur in the European chalk.

We have here to remark on the absence of siliceous animals in this limestone and marl formation, while the so-called Egyptian pebbles and jaspers occupy the same position in horizontal layers as the flints in the North of Europe, appearing as their substitute. But in these jaspers the organic siliceous elements are no longer to be distinctly found by reason of their intermixture with other substances, and their consequent opacity, giving rise to dendritic and other delineations. It seems as if the solution and conversion of the organic into the inorganic in the Egyptian pebbles (*Cailloux d'Egypte*)

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is throughout more perfect than it is in many flints, although the constituent elements of both kinds of stone are very probably quite the same.

On the principal Organic Calcareous Forms which compose the mass of all Chalk.

From what has been already stated, it is evident that the production of the calcareous mass of the chalk is not to be attributed, as formerly conceived, to the larger organic bodies, but to the minuter, and in the greatest measure to such as are invisible, consisting of eight genera of Polythalamia with twenty-five species, and excluding all such as may be distinguished by the naked eye, that is, exceeding $\frac{1}{24}$th of a line in magnitude; the latter, however, are comparatively rare. It is possible that several other, and perhaps many species of the same genera, may yet be discovered in the chalk, as well as other genera, since the investigations hitherto made could only be applied to a minimum of its substance; yet, as these were conducted by me on chalk from many regions, it does not appear probable that other sections of the animal kingdom will be found to have taken so great a share in the formation of chalk as the Polythalamia, the principal prevailing forms of which I have indicated.

From the preceding it is also apparent that the chalk rocks of all countries agree in their constituent organic forms not only according to the zoological class, but also in genera, and for the most part in species likewise; this character being not confined to the white tender writing chalk of Europe, but extending also to the compact limestone rocks of the North of Africa and the West of Asia. Particularly striking is the characteristic persistence of single forms through all these different and widely-separated countries. Thus in all of them are to be found *Rotalia globulosa*, with *Textularia globulosa*, *T. aciculata ?*, and *T. striata*, as well as *Planulina turgida*, thus giving a common character to all these rock formations; and this character becomes the more important, when we consider that these forms are the most numerous, and in fact are the chief constituents of the chalk*.

* The Polythalamian forms which Mr. Lonsdale noticed in the English chalk in 1837 as visible to the naked eye, and amounting to 1000 in one pound of the chalk, and which, with Mr. Lyell, he has named *Lenticulina* and *Discorbis* †, appear, judging by the figures, to be referable to *Rotalia ornata* and *R. globulosa*, including perhaps fragments of *Textularia globulosa*.

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If now the question be asked whether the forms which occur in such masses in chalk belong to it exclusively, and are hence to be considered characteristic of that formation, I am almost disposed to reply in the affirmative. The analogous forms which occur in sea-sand, tertiary sand, and indeed in all modern formations, are viewed for the most part as different and larger species, although of the same genera; and it does not appear that any of these forms can be referred with perfect certainty to such as are now living in the sea.

To the theory of the formation of limestone, the observation is important, that these organic deeply-seated relations are not peculiar to the chalk formation. The tertiary calcareous beds consist, in like manner with the chalk, of multitudes of such Polythalamian animals, which compose in many quarters sandy sea-downs of great extent; and even in the sandy desert of Libya we can recognize distinct Polythalamia. On the other hand, having succeeded in discovering microscopic Polythalamia in the compact flints of the Jura limestone from Cracow, which are of decidedly different forms from those of the chalk, the calcareous animals being *Nodosaria urceolata*, n. sp., and *Soldania elegans*, n. sp., and the siliceous *Pyxidicula prisca*?, with *fragments of soft sponges*, it becomes apparent that such invisible organic bodies were also present in the formation of the Jura limestone.

On the Geographical Distribution of Living Polythalamia on the African and Asiatic Coasts of the Mediterranean, and in the Red Sea.

The materials collected by Dr. Hemprich and myself in the Mediterranean refer to four points on the Libyan coast, and one point on the Syrian coast. In regard to a second point on the latter coast (St. Jean d'Acre), I have acquired a knowledge of some forms from the collection of Dr. Parthey.

From the Red Sea nine forms were made known to us by d'Orbigny, collected from sand presented to him by Deshayes. But from the collections made by Dr. Hemprich and myself from thirteen points along the whole length of the Red Sea, it appears that very numerous forms exist. Of seven of those points, one occurs on the western (African) coast at Suez, and six on the eastern (Arabian) coast, namely, at Tor, Erraie and el Ard, Moileh, el Wusch and Gumfŭde; and of the remaining six, five are islands on the Arabian side, namely, Sanafer,

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Maksure, Barkan, Sanac and Ketumbul, and one an island on the African side of the Red Sea, namely, Massaua.

It is possible that by repeated and closer examination of the marine productions collected by us, many other Polythalamia may be found besides those already discovered. In the mean time, as a preliminary, I have drawn up a list of the species hitherto met with*. From this it results that the total number of species of Polythalamia observed in the Red Sea are *fifty*, and in the Mediterranean, on the Libyan and Syrian coasts, *twenty-seven*. The new species derived from the two seas amount to *fifty-four*, of which *twenty-seven* species are peculiar to the Red Sea, and *seventeen* are common to both seas. Particularly worthy of notice is the wide distribution and massy development of the *Peneroplis planatus* and *Sorites Orbiculus*, which are rare on the European coast. These forms are not only present almost everywhere in the East, but constitute the predominant masses. On the other hand, the *Rotalia Beccarii*, which composes the Italian hills, occurs only singly and very rarely in the Red Sea; and I nowhere found it on the Libyan and Syrian coasts. The *Sorites Orbiculus* I have also from St. Domingo.

In reviewing these subjects, even a superficial comparison of them with the contents of the chalk and chalk marl, is attended with the striking result, that none of these living forms are found among the animalcules of the chalk, not even among those which compose the compact limestone of the Egyptian and Arabian rocks, and which are still partly washed by the sea near Hamam Faraūn.

Remarks on Polythalamia.

After a preliminary view of the researches of earlier labourers in this branch of zoological inquiry, Dr. Ehrenberg observes:—A lively interest respecting the minute Polythalamian bodies which enter into the composition of sea-sand was excited anew by the work of Alcide d'Orbigny in 1826, in which are contained a great number of new species, while many of those which were previously known are examined with greater

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* Of d'Orbigny's nine species from the Red Sea, there are three which I cannot identify, namely, *Triloculina bicarinata, Quinqueloculina limbata*, and *Q. punctata*; but the other six are probably those with which I have become acquainted, and to which I have therefore given the same names, namely, *Textularia communis, Calcarina Defrancii, C. Gaudichaudii, Quinqueloculina sulcata*, and *Vertebralina striata*. His *Assilina* (*Nummulina*) *nitida* I hold to be the *Sorites Orbiculus*.

Although I possess and have compared many of the Polythalamia which have been described by d'Orbigny derived from the same localities, yet I am in want of a great number of the originals named by him, and as this author has generally given new names unaccompanied by descriptions, I have not in most cases been able to determine to what form the name given by him belongs.

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It is possible that by repeated and closer examination of the marine productions collected by us, many other Polythalamia may be found besides those already discovered. In the mean time, as a preliminary, I have drawn up a list of the species hitherto met with*. From this it results that the total number of species of Polythalamia observed in the Red Sea are *fifty*, and in the Mediterranean, on the Libyan and Syrian coasts, *twenty-seven.* The new species derived from the two seas amount to *fifty-four*, of which *twenty-seven* species are peculiar to the Red Sea, and *seventeen* are common to both seas. Particularly worthy of notice is the wide distribution and massy development of the *Peneroplis planatus* and *Sorites Orbiculus*, which are rare on the European coast. These forms are not only present almost everywhere in the East, but constitute the predominant masses. On the other hand, the *Rotalia Beccarii*, which composes the Italian hills, occurs only singly and very rarely in the Red Sea; and I nowhere found it on the Libyan and Syrian coasts. The *Sorites Orbiculus* I have also from St. Domingo.

In reviewing these subjects, even a superficial comparison of them with the contents of the chalk and chalk marl, is attended with the striking result, that none of these living forms are found among the animalcules of the chalk, not even among those which compose the compact limestone of the Egyptian and Arabian rocks, and which are still partly washed by the sea near Hamam Faraūn.

Remarks on Polythalamia.

After a preliminary view of the researches of earlier labourers in this branch of zoological inquiry, Dr. Ehrenberg observes:—A lively interest respecting the minute Polythalamian bodies which enter into the composition of sea-sand was excited anew by the work of Alcide d'Orbigny in 1826, in which are contained a great number of new species, while many of those which were previously known are examined with greater

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care, and an improved and easier view is taken of the whole subject. By his active exertions he had collected between 600 and 700 species from the sea-sand of France, Italy, England, the Isle of France, Sandwich Islands, the Malouine and Marian Isles, &c., of which, however, only 425 received names. The whole mass of these microscopic animalcules, which he again decidedly associates with the Mollusks and Cephalopods, but in a distinct order under the name of *Foraminifères*, are distributed by him into five families, according to the spiral or other form in the grouping of the cells; these families comprising fifty-two genera. On this work Deshayes made various critical remarks in the *Dictionnaire Classique*. D'Orbigny expressly states that the animal of the Polythalamia (his Foraminifera) resembles the Sepia in the structure of its body, although much smaller, and then proceeds to give the essential characters of the living body of the Polythalamia, yet without naming specifically or generically any one animal from which they were taken*.

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Both Blainville and Dujardin have made the correct observation that the minute shells of the Polythalamia are external cases, and not, as incorrectly viewed by Denys de Montfort and Alcide d'Orbigny, internal bones. Yet in referring the microscopic so-called Cephalopods to the Infusoria, Dujardin commits a mistake†. It was this contradiction between observers that induced Férussac, in his great work, *Histoire Naturelle des Mollusques*, to exclude the Foraminifers from the class of the Mollusks; and others entertained similar objections, yet without assigning to them a correct position.

In the year 1831 I laid before the Academy contributions to the knowledge of Coral animals, with an attempt to class them physiologically; which attempt was entirely founded on my own observations of the living animalcules, when, accompanied by Dr. Hemprich, I travelled on the Red Sea in the years 1823 and 1825. In that work I designated the Coral animals as composed of two strongly marked organically distinct groups, under the names of *Anthozoa* and *Bryozoa*. In the year 1831 also, I communicated in the *Symbolæ Physicæ* the first development made of the complicated structure of the *Halcyonella stagnorum*, one of the Bryozoa, and showed that it was quite similar to that of Flustra.

The researches of Dujardin in 1835 gave an entirely new direction to the ideas which had been formed of the Polythalamia, showing that not a trace of resemblance was to be found between them and Sepia; on the contrary, the greatest simplicity of structure became apparent, bespeaking a simple ani-

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It results clearly from what has been said in respect of these species, which are so common and widely distributed, and which have hitherto been designated in systems as small Nautili, that the straight-jointed shells of Nodosaria (formerly viewed as Orthocera), as well as the spiral shells of Rotalia, Cristellaria, &c. (considered as Nautili or Ammonites), and the shells of Biloculina resembling vermiform tubes (*Serpula*), are none of them internal calcareous parts which were encased by an animal body, similar to the internal bone of Sepia, or the cylindrical spiral bone of Spirula; but, on the contrary, that they are external calcareous shells, bearing analogy to those of Mollusks, or more correctly to those of Flustra and Cellepora, which, after separation by an acid, disclose and render visibly free the internal simple body or the Polypary, exhibiting precisely the same form. If the shell of Polythalamia be frequently perforated with pores, this is no proof that no other openings exist, or that the animals receive nourishment through many tubes, for the same structure is not unfrequently found in Flustra accompanied with the peculiar opening from which the fore-part of the animal body may be protruded; and in these exist also fringe-like filaments, which are extensile and retractile, and by no means to be compared to the pseudopodia or variable feet of Amoeba, but probably bear analogy to the mantle fringes of many Mollusks, applicable to the purposes of creeping and attachment, and for which perhaps they were specially designed. Moreover, Flustra possess a distinct large animal organization; and the siliceous Infusoria, and probable eggs found in Polythalamia, clearly bespeak in them also similar relations, the discovery of which, however, had hitherto been prevented by the calcareous encasement and the minuteness of the objects.

It has resulted from the examination of the soft small animal bodies of living Polythalamia, that while many resemble Flustra or Eschara assembled in families or polyparies, each such family being often composed of hundreds of much mi-

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nuter single animalcules, many others are single animals after the manner of Mollusks. Hence arise external characters and forms which have often a reference to very different relations, which it is first necessary to distinguish before we can succeed in obtaining a clear view of the whole. The assiduous and careful labours of d'Orbigny retain their full value, serving as a basis to all future researches; and if in the present communications I shall have succeeded in turning the inquiry into a more physiological channel, my object will be attained.

To the term *Polythalamia*, (originally introduced by Dr. Breyn, of Danzig, in 1732,) a different extension or signification under other names has been given by different authors. To remove this unsteadiness and wanton change of names, which only lead to obscurity, it appears advisable to apply the term Polythalamia, in preference, as Soldani had done, to that group in which the animalcules actually live in many cells, and do not, like the Nautili, possess many empty cells. This distinction, that the animal of the Polythalamia has no empty cells, but that all its cells are simultaneously occupied, is of particular importance in their systematic arrangement among other animal bodies. Where there are many cells, they consist either of so many single animals, the whole constituting a polypary, or of organically filled integrant portions of one and the same individual forming groups. Both structures are foreign to the true Cephalopods. The shell-bearing Cephalopods may with Linnæus be divided into the *unilocular* and *multilocular*.

On the other hand, the want of a sipho which has been assigned as a character of Polythalamia, and from which they were named *Asiphonoidea* by De Haan, is incorrect, inasmuch as many really possess a part which may be fully compared to a sipho, if not in function, yet in form, namely, the tube which connects the separate cells of Nodosarina and of all individual many-celled forms. It is only in the *Miliolina* family among the simple Polythalamia, and it is only in the families of *Asterodiscina* and *Soritina* among those forming polyparies, that the want of a sipho is really necessary, because they live individually in single cells. But all the Nodosarina, Textularina, Uvellina, Rotalina, and Plicatilia among the simple Polythalamia, and the Frumentarina, Helicosorina, and Alveolinea among those which form polyparies, possess tubes of connexion between the cells, which very frequently resemble also in form the sipho of the Nautilus. D'Orbigny, it is true, states also that the cells of Foraminifers are connected by several openings; that, however, proceeds from an erroneous view, for such Polythalamia alone present several openings at the border of the cells, whose calcareous surface is interrupted in the form of a net-work, exhibiting often a relation analogous

nuter single animalcules, many others are single animals after the manner of Mollusks. Hence arise external characters and forms which have often a reference to very different relations, which it is first necessary to distinguish before we can succeed in obtaining a clear view of the whole. The assiduous and careful labours of d'Orbigny retain their full value, serving as a basis to all future researches; and if in the present communications I shall have succeeded in turning the inquiry into a more physiological channel, my object will be attained.

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to that which is frequent in Madrepora and Astræa, in which the soft body is not divided or sharply cut off by compact calcareous plates, but the soft parts appear interwoven with minute calcareous rods, in a lattice-like manner. These numerous small connecting openings, which are sometimes visible in some of the Rotalia and Rosalina, and also in the Textularia, I do not consider essential, but hold that the true channel of connexion has always a large diameter, and is simple for each single animal. The erroneous view of d'Orbigny and of all his followers becomes so complicated, that polyparies are held to be single animals, and consequently the various connecting openings to be those of a simple individual.

With respect to d'Orbigny's genus *Nummulina*, although it has derived advantage from his diligent investigations, I consider it as composed of very heterogeneous elements, which belong to quite different divisions of animals. Some species of the sub-genus *Assilina*, and perhaps all of them, may belong to the families *Soritina* and *Asterodiscina*, while the *Assilina nitida* of the Red Sea is assuredly Forskål's *Nautilus Orbiculus*, that is, *Sorites Orbiculus*.

I am of opinion that all those species which are provided with visible traces of mouths or openings, as in Lamarck's genus *Lenticulina* with d'Orbigny's character of Nummulina, are to be received among the Polythalamia; but that all such species as have the form of a lens or disc, and are provided with internal spiral cells, but without a trace of such mouths, the cells being moreover separated from the external surface by thick calcareous layers, are to be considered as internal bones. These mouthless Nummulina are rather to be ranged with the Velellida of the Acalepha along with *Porpita*, where similar internally cellular coin-shaped bones exist. The considerable size of many Nummulina is also striking and foreign to Polythalamia, but agrees very well with the family of the Velellida, as also in the want of traces of the attachment of muscles, and in the want of a sipho or channel of connexion between the cells. Until better informed, therefore, I decidedly exclude the mouthless Nummulina from the Polythalamia, and retain only Lamarck's Lenticulina in the sense attached to d'Orbigny's Nummulina in a young state.

The distinctive character of the Polythalamia, when compared with their nearest relatives the *Flustra*, *Eschara*, *Cristatella*, &c., consists in the shell, and in their freedom of motion. But with this may be combined the power of attaching itself to other bodies, just as in the *Cristatella* (or *Hydra* also) which often remains long attached, and then creeps again. Those bodies which are apparently Polythalamian, but are really adherent and immoveable, belong to the *Cellepora*,

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Flustra, *Tubulipora*, and similar forms. The simplest Polythalamian form is the *Miliola* in Dujardin's sense, if there be really such self-existent animals, and they be not the young of others, or of many-celled forms most nearly related to Biloculina. And perhaps *Gromia oviformis* might be so viewed, should it not prove to be a *Difflugia* (an Infusoria). In this series I myself place provisionally, as doubtful, those numerous small globules of the sand of Rimini which have no distinct opening, or sometimes present a very minute one. The next simplest form is that of a simple straight row of cells, as in the *Nodosaria*, a jointed continued development of a simple body. *Textularina*, *Uvellina* and *Rotalina* (Lenticulina), may, as to external form, be viewed as Nodosarina developed in another manner, namely, in botryoidal or spiral forms.

I have here to make a remark that appears important. In the entire vast mass of known Polythalamia, a case or vestment prevails which is either cuticular or composed of a calcareous substance, while in Infusoria either a cuticular or siliceous substance prevails, so that hitherto no calcareous-shelled Infusoria nor siliceous-shelled Polythalamia had presented themselves. Yet among the fossil microscopic organisms of the chalk marl of Sicily, we find intermingled with the Infusoria shells bodies whose forms may be ranked with Polythalamia, namely, with Nodosarina, but the shells of which are siliceous, insoluble in acids, and which to the eye have a more transparent vitreous aspect than the calcareous shells when penetrated by balsam. I have hence been induced to place these siliceous-shelled forms, until a further knowledge may be acquired of their organization, among the polygastric Infusoria near the shelled Amoeba, in a separate family, under the name of *Arcellina composita*, or *Polycystina**. Such siliceous-shelled *Polycystina*, resembling calcareous-shelled Polythalamia, are the genera *Lithocampe*, *Cornutella* and *Haliomma*, with several species.

I wish here to draw attention to a small character hitherto unregarded, which is distinctive of true Polythalamia, and often even of their fragments. It consists in this, that in the tube or channel of connexion between the cells, the mouth of the tube which belongs to the earlier smaller cell is overgrown and surrounded by the succeeding larger cell. If the mouth of the last cell be prolonged in a beak-like form, we find in all the earlier smaller cells a distinct tube, quite similar to the hard remains of the sipho in the Nautilus; but so placed that the tube always projects forward from the smaller into the larger cell, and never backward from the larger into the smaller

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The tabular view which I have given of the Bryozoa, founded as it is on the new observations which I have made, is drawn up with special regard to a definite expression of fossil phænomena, the ancient names of d'Orbigny being mostly retained. This very diligent precursor in these studies first laid down a foundation rich in forms and systematically ordered, which may serve for all future investigations, and has given names to families which are well adapted to his purpose; but these I have been obliged to alter, yet not arbitrarily, inasmuch as from the difference of our views it became necessary to separate from each other the forms which constitute his families, according as they are either simple Polythalamia, or Polythalamia composing polyparies.

Since the foregoing pages were drawn out, a newer work by Dr. Ehrenberg has made its appearance, embracing communications made to the Berlin Academy, on the continued researches of the author between September 1839 and August 1840, and bearing the title, "On the numerous Living Species of Animals found in the Chalk Formation*." Of this very interesting publication I had designed presenting an abstract, but having learned that a complete English edition of the work is about to appear† accompanied by the engravings, I now confine myself to a few notices immediately connected with the preceding part of this paper.

In this memoir Dr. Ehrenberg repeats his objections to the views entertained by MM. Alcide d'Orbigny and Dujardin. It has been seen, that to the Polythalamia, whose minute and often microscopic calcareous shells compose in inconceivable numbers, and in now nearly 1000 known different forms, the principal mass of chalk rocks and of many sands of the sea, M. d'Orbigny had several years since ascribed an external animal bearing the form of a Sepia, the small shell itself, which

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often resembles an Ammonite or Nautilus, being considered as the internal bone. On the other hand, at a later period, M. Dujardin denied that these animals possessed any organic structure, stating that they consisted simply of an animated slime capable of extension, encased by an indurated external shell, and associating them with the pseudopodian Amoeba of the Infusoria. Dr. Ehrenberg now further demonstrates, by figures and descriptions, their true organic structure, thus fully establishing his former positions, both as to simple Polythalamia and Polythalamia forming Polyparies. He proves that they are not internal bones, but external shells encasing a soft body, the shell being perforated, as it were, in all parts by numerous pores, from which the animal projects long filaments, capable at will of extension, retraction and bifid division, and productive of locomotion. The author further observes: M. Dujardin has, in August 1840, presented to the Paris Academy a *Mémoire sur une Classification des Infusoires en rapport avec leur organisation*, in which a new arrangement of the Infusoria is exhibited, and in this the Polythalamia are again introduced as *Rhizopodes* in association with *Amoeba* and *Actinophrys* of the Infusoria, forming a separate family. If, however, anatomical and physiological details are to be taken into account when we proceed to the systematic arrangement of different organic bodies, and we are not governed merely by the relations of external forms, M. Dujardin's arrangement cannot be deemed a happy one. He has in no case shown a polygastric structure in the Rhizopodes, and that it is not polygastric is proved anew by my investigations now communicated.

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* *Ueber noch zahlreich jetzt-lebende Thierarten der Kreidebildung*, pp. 94, with four plates, Berlin, 1840.

† In the Scientific Memoirs of Mr. R. Taylor. Its publication cannot fail to prove very acceptable to British Naturalists in general.

It has been shown in a former part of this paper that Dr. Ehrenberg had recognized six species of Infusoria in the chalk formation, so closely resembling living species as not to be distinguished from them, and hence he was led to give to them the same names; namely, *Eunotia Zebra*, *Fragilaria rhabdosoma*, *Fragilaria striolata ?*, *Gallionella aurichalca*, *Navicula ventricosa*, and *Synedra ulna*. He had also referred, with a mark of interrogation, the following four species of calcareous-shelled Polythalamia to the white chalk, in which they are very extensively distributed, namely, *Globigerina bulloides*, *Globigerina helicina*, *Rosalina globularis*, and *Textilaria aciculata*, all of which were stated by M. d'Orbigny to have occurred in the living state only in the Adriatic Sea and the Ocean. If any doubt had existed as to the identity of all these fossil and living species, it has been completely removed by the later researches of Dr. Ehrenberg, by which the actual number of known species found in the chalk formation and in

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the living state has been extended to fifty-seven, namely, of calcareous-shelled Polythalamia nine species, and of siliceous-shelled Infusoria forty-eight species. The following is a list of these species and of the localities in which they occur, both in the living and fossil state. In the fossil localities, W. C. signifies white chalk, C. M. chalk marl, and C. C. compact chalk.

Calcareous-shelled Polythalamia.

	Living.	Fossil.
1. Globigerina bulloides	In the Adriatic Sea and the Ocean	W. C. Denmark.
2. —— helicina	——	W. C. Cattolica.
3. Rosalina globularis	——	W. C. Gravesend.
4. Planulina (Synon. Rotalia) ocellata	North Sea, near Cuxhaven	W. C. Cattolica.
5. Rotalia globulosa	——	W. C. in Russia, Poland, Prussia, Denmark, England, France and Sicily; and C. M. in Greece, Zante, Sicily and Oran.
6. —— stigma	——	W. C. Cattolica. C. M. Caltasinetta.
7. —— (Synon. Planulina?) turgida	——	W. C. England, France, Prussia, Denmark. C. M. Oran. C. C. Egypt and Arabia.
8. Textilaria aciculata	——, and Adriatic and the Ocean	W. C. Prussia, Denmark, England and Sicily. C. M. Greece. C. C. Egypt and Arabia.
9. —— globulosa	North Sea.	W. C. of all European countries, from Wolsk to Ireland. C. M. Sicily, Oran, and Greece. C. C. Egypt and Arabia.

Siliceous-shelled Infusoria.

10. Actinocyclus quinarius	North Sea, Tjörn Isle in the Cattegat	C. M. Caltasinetta.
11. —— biternarius	North Sea, Tjörn	C. M. Oran and Caltasinetta.
12. —— senarius	North Sea, Cuxhaven, Christiania, Tjörn	C. M. Oran, Caltasinetta, and Greece.
13. —— septenarius	North Sea in the Cattegat	C. M. Oran, Caltasinetta, and Zante.
14. —— octonarius	——	C. M. Oran and Caltasinetta.
15. —— nonarius	N. Sea, Cattegat near Tjörn.	C. M. Oran.
16. —— denarius	——	C. M. Oran.
17. —— undenarius	——, and Bay of Christiania.	C. M. Oran and Zante.
18. —— bisenarius	Cattegat near Tjörn	C. M. Oran.
19. —— quindenarius	——	C. M. Oran.
20. Amphitetras antediluviana	——	C. M. Oran and Greece.

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12. —— senarius	North Sea, Cuxhaven, Christiania, Tjörn . . .	C. M. Oran, Caltasinetta, and Greece.
13. —— septenarius . .	North Sea in the Cattegat	C. M. Oran, Caltasinetta, and Zante.
14. —— octonarius . . .	——————————	C. M. Oran and Caltasinetta.
15. —— nonarius	N. Sea, Cattegat near Tjörn.	C. M. Oran.
16. —— denarius	——————————	C. M. Oran.
17. —— undenarius . . .	——————————, and Bay of Christiania.	C. M. Oran and Zante.
18. —— bisenarius	Cattegat near Tjörn . . .	C. M. Oran.
19. —— quindenarius . .	—————————— . . .	C. M. Oran.
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12. —— senarius	North Sea, Cuxhaven, Christiania, Tjörn . . .	C. M. Oran, Caltasinetta, and Greece.
13. —— septenarius . .	North Sea in the Cattegat	C. M. Oran, Caltasinetta, and Zante.
14. —— octonarius . . .	———	C. M. Oran and Caltasinetta.
15. —— nonarius	N. Sea, Cattegat near Tjörn.	C. M. Oran.
16. —— denarius	———	C. M. Oran.
17. —— undenarius . . .	———, and Bay of Christiania.	C. M. Oran and Zante.
18. —— bisenarius	Cattegat near Tjörn . . .	C. M. Oran.
19. —— quindenarius . .	——— . . .	C. M. Oran.
20. Amphitetras antediluviana	——— . . .	C. M. Oran and Greece.

	Living.	Fossil.
21. Biddulphia pulchella.	Baltic, N. Sea, Mediterranean, and Ocean near Cuba	C. M. Greece.
22. Cocconema lanceolatum	Brackish and fresh waters.	C. M. Greece.
23. Coscinodiscus Argus.	North Sea, Cuxhaven . .	C. M. Caltasinetta and Oran.
24. —— eccentricus . . .	————, Tjörn in Cattegat, and Mexican Gulf, Vera Cruz.	C. M. Oran.
25. —— lineatus	North Sea, Cuxhaven . .	C. M. Caltasinetta.
26. —— minor	———— . .	C.M. Caltasinetta, Oran, and Zante.
27. —— Oculus Iridis . .	———— . .	C. M. Greece.
28. —— Patina	———— . .	C. M. Zante.
29. —— radiatus	————, and Baltic, Wismar.	C. M. Oran, Caltasinetta, and Zante.
30. Dictyocha sulcata . .	North Sea near Tjörn . .	C. M. Caltasinetta, Oran, Zante, and Greece.
31. —— Fibula	N. Sea, Christiania and Tjörn, & Baltic, Wismar	C. M. Oran and Caltasinetta.
32. —— Pentasterias . .	N. Sea, Christiania haven.	C. M. Zante.
33. —— Speculum . . .	N. Sea, Cuxhaven, Christiania and Tjörn, Baltic, near Kiel	C. M. Caltasinetta, Oran, Zante, and Greece.
34. Eunotia granulata . .	Brackish and fresh waters.	C. M. Greece.
35. —— Zebra	Berlin fresh waters	C. M. Greece.
36. Fragilaria rhabdosoma	Berlin, Halle, Copenhagen, Sweden	W. C. Gravesend
37. —— striolata	. . . .	W. C. Gravesend.
38. Gallionella aurichalca	Berlin fresh waters, Leipzig, Thuringia, Franconia, Würzburg, Stuttgart, and on rocks near the Faroe Isles	W. C. Rügen.
39. —— sulcata	North Sea, Cuxhaven . .	C. M. Caltasinetta, Oran, Zante, and Greece.
40. Grammatophora africana	N. Sea, Heligoland, Tjörn	C. M. Oran.
41. —— angulosa	North Sea, Tjörn	C. M. Oran.
42. —— oceanica	Callao in Peru, Vera Cruz in Mexico, Tjörn in Cattegat, Wismar in Baltic, and the Mediterranean.	C. M. Oran.
43. —— undulata	Among marine Confervæ near Vera Cruz.	C. M. Greece.
44. Haliomma radians . .	North Sea, Cuxhaven . .	C. M. Greece.
45. Navicula Didymus. .	N. Sea, Cuxhaven, Baltic, Wismar	C. M. Caltasinetta.
46. —— Entomon	N. Sea, Christiania haven.	C. M. Greece.
47. —— norwegica . . .	————	C. M. Greece.
48. —— quadrifasciata .	————, and Tjörn Isle.	C. M. Greece.
49. —— ventricosa	Paris, Berlin, Saxony, Bohemia, Buchtarma in Altai, and Irtysch.	C. M. Oran.
50. —— viridula	Berlin fresh waters, Weissenfels in Saxony, and Wismar in Mecklenburg.	C. M. Greece.

	Living.	Fossil.
21. Biddulphia pulchella.	Baltic, N. Sea, Mediterranean, and Ocean near Cuba	C. M. Greece.
22. Cocconema lanceolatum	Brackish and fresh waters.	C. M. Greece.
23. Coscinodiscus Argus.	North Sea, Cuxhaven . .	C. M. Caltasinetta and Oran.
24. —— eccentricus . . .	——, Tjörn in Cattegat, and Mexican Gulf, Vera Cruz.	C. M. Oran.
25. —— lineatus	North Sea, Cuxhaven . .	C. M. Caltasinetta.
26. —— minor	—— . .	C.M. Caltasinetta, Oran, and Zante.
27. —— Oculus Iridis . .	—— . .	C. M. Greece.
28. —— Patina	—— . .	C. M. Zante.
29. —— radiatus	——, and Baltic, Wismar.	C. M. Oran, Caltasinetta, and Zante.
30. Dictyocha sulcata . .	North Sea near Tjörn . .	C. M. Caltasinetta, Oran, Zante, and Greece.
31. —— Fibula	N. Sea, Christiania and Tjörn, & Baltic, Wismar	C. M. Oran and Caltasinetta.
32. —— Pentasterias . .	N. Sea, Christiania haven.	C. M. Zante.
33. —— Speculum . . .	N. Sea, Cuxhaven, Christiania and Tjörn, Baltic, near Kiel	C. M. Caltasinetta, Oran, Zante, and Greece.
34. Eunotia granulata . .	Brackish and fresh waters.	C. M. Greece.
35. —— Zebra	Berlin fresh waters	C. M. Greece.
36. Fragilaria rhabdosoma	Berlin, Halle, Copenhagen, Sweden	W. C. Gravesend
37. —— striolata	. . . .	W. C. Gravesend.
38. Gallionella aurichalca	Berlin fresh waters, Leipzig, Thuringia, Franconia, Würzburg, Stuttgart, and on rocks near the Faroe Isles	W. C. Rügen.
39. —— sulcata	North Sea, Cuxhaven . .	C. M. Caltasinetta, Oran, Zante, and Greece.
40. Grammatophora africana	N. Sea, Heligoland, Tjörn	C. M. Oran.
41. —— angulosa	North Sea, Tjörn	C. M. Oran.
42. —— oceanica	Callao in Peru, Vera Cruz in Mexico, Tjörn in Cattegat, Wismar in Baltic, and the Mediterranean.	C. M. Oran.
43. —— undulata	Among marine Confervæ near Vera Cruz.	C. M. Greece.
44. Haliomma radians . .	North Sea, Cuxhaven . .	C. M. Greece.
45. Navicula Didymus. .	N. Sea, Cuxhaven, Baltic, Wismar	C. M. Caltasinetta.
46. —— Entomon	N. Sea, Christiania haven.	C. M. Greece.
47. —— norwegica . . .	——	C. M. Greece.
48. —— quadrifasciata .	——, and Tjörn Isle.	C. M. Greece.
49. —— ventricosa	Paris, Berlin, Saxony, Bohemia, Buchtarma in Altai, and Irtysch.	C. M. Oran.
50. —— viridula	Berlin fresh waters, Weissenfels in Saxony, and Wismar in Mecklenburg.	C. M. Greece.

	Living.	Fossil.
21. Biddulphia pulchella.	Baltic, N. Sea, Mediterranean, and Ocean near Cuba	C. M. Greece.
22. Cocconema lanceolatum	Brackish and fresh waters.	C. M. Greece.
23. Coscinodiscus Argus.	North Sea, Cuxhaven . .	C. M. Caltasinetta and Oran.
24. —— eccentricus . . .	————————, Tjörn in Cattegat, and Mexican Gulf, Vera Cruz.	C. M. Oran.
25. —— lineatus	North Sea, Cuxhaven . .	C. M. Caltasinetta.
26. —— minor	———————— . .	C.M. Caltasinetta, Oran, and Zante.
27. —— Oculus Iridis . .	———————— . .	C. M. Greece.
28. —— Patina	———————— . .	C. M. Zante.
29. —— radiatus	————————, and Baltic, Wismar.	C. M. Oran, Caltasinetta, and Zante.
30. Dictyocha sulcata . .	North Sea near Tjörn . .	C. M. Caltasinetta, Oran, Zante, and Greece.
31. —— Fibula	N. Sea, Christiania and Tjörn, & Baltic, Wismar	C. M. Oran and Caltasinetta.
32. —— Pentasterias . .	N. Sea, Christiania haven.	C. M. Zante.
33. —— Speculum . . .	N. Sea, Cuxhaven, Christiania and Tjörn, Baltic, near Kiel	C. M. Caltasinetta, Oran, Zante, and Greece.
34. Eunotia granulata . .	Brackish and fresh waters.	C. M. Greece.
35. —— Zebra	Berlin fresh waters	C. M. Greece.
36. Fragilaria rhabdosoma	Berlin, Halle, Copenhagen, Sweden	W. C. Gravesend
37. —— striolata	. . . .	W. C. Gravesend.
38. Gallionella aurichalca	Berlin fresh waters, Leipzig, Thuringia, Franconia, Würzburg, Stuttgart, and on rocks near the Faroe Isles	W. C. Rügen.
39. —— sulcata	North Sea, Cuxhaven . .	C. M. Caltasinetta, Oran, Zante, and Greece.
40. Grammatophora africana	N. Sea, Heligoland, Tjörn	C. M. Oran.
41. —— angulosa	North Sea, Tjörn	C. M. Oran.
42. —— oceanica	Callao in Peru, Vera Cruz in Mexico, Tjörn in Cattegat, Wismar in Baltic, and the Mediterranean.	C. M. Oran.
43. —— undulata	Among marine Confervæ near Vera Cruz.	C. M. Greece.
44. Haliomma radians . .	North Sea, Cuxhaven . .	C. M. Greece.
45. Navicula Didymus. .	N. Sea, Cuxhaven, Baltic, Wismar	C. M. Caltasinetta.
46. —— Entomon	N. Sea, Christiania haven.	C. M. Greece.
47. —— norwegica . . .	————————	C. M. Greece.
48. —— quadrifasciata .	————————, and Tjörn Isle.	C. M. Greece.
49. —— ventricosa	Paris, Berlin, Saxony, Bohemia, Buchtarma in Altai, and Irtysch.	C. M. Oran.
50. —— viridula	Berlin fresh waters, Weissenfels in Saxony, and Wismar in Mecklenburg.	C. M. Greece.

	Living.	Fossil.
51. Peridinium pyrophorum	Baltic, near Kiel	Flints of the W. C. near Gravesend, and Flints of the plain of North Germany near Delitzsch.
52. Striatella arcuata	Gulf of Flensburg, Breakers near Gothenburg.	C. M. Oran.
53. Synedra ulna	Baltic near Wismar, Berlin fresh waters, North of Germany, Denmark, Scotland, Holland, the Ural, and perhaps Isle of France, and Mascarene Isles	C. M. Oran.
54. Tessella Catena	Breakers near Gothenburg and Berlin waters.	C. M. Caltasinetta.
55. Triceratium Favus	North Sea, Cuxhaven	C. M. Greece.
56. Xanthidium furcatum	Berlin	Flints of W. C. Gravesend, and Flints of Delitzsch.
57. —— hirsutum	Peat waters near Berlin.	Flints of W. C. Gravesend, and Flints of Delitzsch.

Of these fifty-seven species, thirty belong to the geologically acknowledged chalk and its Sicilian marls. The remainder from Oran, Greece (probably Egina), and Zante, though perhaps from beds not equally well defined by relative position as chalk marls, yet occurring, as they do, with numerous decided calcareous and siliceous animals of the chalk,—the geological relations of these species may also be considered as firmly established.

These new discoveries naturally lead to the conclusion that we have now no very definite boundary between secondary and tertiary tracts, and that the first dawn or eocene period of the present living organic creation, must be sought for deeper than the chalk formation; a view that appears to be confirmed by the occurrence of a living *Trochus* below the chalk, of the *Paludina vivipara* and *Cyclas cornea* in the Weald Clay, and of the *Terebratula caput serpentis* in the Upper Oolite. But as this and other interesting conclusions and views entertained by the author will be shortly laid open to the reader, with a full detail of the progressive researches made, I shall not now enter further upon the important matter contained in the volume.

	Living.	Fossil.
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55. Triceratium Favus	North Sea, Cuxhaven	C. M. Greece.
56. Xanthidium furcatum	Berlin	Flints of W. C. Gravesend, and Flints of Delitzsch.
57. —— hirsutum	Peat waters near Berlin.	Flints of W. C. Gravesend, and Flints of Delitzsch.

Of these fifty-seven species, thirty belong to the geologically acknowledged chalk and its Sicilian marls. The remainder from Oran, Greece (probably Egina), and Zante, though perhaps from beds not equally well defined by relative position as chalk marls, yet occurring, as they do, with numerous decided calcareous and siliceous animals of the chalk,—the geological relations of these species may also be considered as firmly established.

These new discoveries naturally lead to the conclusion that we have now no very definite boundary between secondary and tertiary tracts, and that the first dawn or eocene period of the present living organic creation, must be sought for deeper than the chalk formation; a view that appears to be confirmed by the occurrence of a living *Trochus* below the chalk, of the *Paludina vivipara* and *Cyclas cornea* in the Weald Clay, and of the *Terebratula caput serpentis* in the Upper Oolite. But as this and other interesting conclusions and views entertained by the author will be shortly laid open to the reader, with a full detail of the progressive researches made, I shall not now enter further upon the important matter contained in the volume.

	Living.	Fossil.
51. Peridinium pyrophorum	Baltic, near Kiel	Flints of the W. C. near Gravesend, and Flints of the plain of North Germany near Delitzsch.
52. Striatella arcuata	Gulf of Flensburg, Breakers near Gothenburg.	C. M. Oran.
53. Synedra ulna	Baltic near Wismar, Berlin fresh waters, North of Germany, Denmark, Scotland, Holland, the Ural, and perhaps Isle of France, and Mascarene Isles	C. M. Oran.
54. Tessella Catena	Breakers near Gothenburg and Berlin waters.	C. M. Caltasinetta.
55. Triceratium Favus	North Sea, Cuxhaven	C. M. Greece.
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APPENDIX.

Closely connected with the preceding subjects is the valuable Memoir of M. Alcide d'Orbigny, which has recently appeared, entitled, "On the Foraminifers of the White Chalk of the Paris Basin*." The subjoined extracts may serve to convey a view of the general scope of the work, which, placed in parallel with that of Dr. Ehrenberg, cannot but excite a double interest in the mind of the reader.

Previously to entering upon the direct object of the Memoir, M. d'Orbigny indulges in a few general reflections.

Let us, says the author, cast a rapid glance upon what has existed and upon what still exists in nature, in reference to the Foraminifers. We have found them distributed through the oolite series, extending from the lias to the uppermost beds; but in the cretaceous system they appear still more numerously and more varied in their forms. The Neocomian beds, those of the gault and the green sand, contain many; but in proportion as we ascend from the lower to the higher strata, they increase infinitely. In these latter the rock may be said to be often composed of them, and, as an example, we may mention the largest of the Pyramids of Egypt. In the white chalk the number is nearly as great as in those seas in which they now most abound. In a word, we have found Foraminifers in the cretaceous basins of the Seine, the Loire, the Gironde, and of the whole South of France, and in Belgium.

If we pass to the tertiary tracts, a whole world is opened to us. The multiplied Foraminifers which appear in the basins of Paris, Bourdeaux, Touraine, Italy, Austria, Germany, England, and Belgium, often form there the greater part of the mass. A bed of considerable thickness in the environs of Gentilly, near Paris, is entirely composed of them, the Foraminifers being in contact with each other, scarcely united by a slight cement. In a cubical inch of the rock we have found *fifty-eight thousand*, which is equal to *three thousand millions* in a metre, and shows what myriads may exist in the Paris basin. These small bodies, which we thus see forming entire beds in the lowest portions of the tertiary series, are not less common in the higher stages; for in Austria, and

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in the environs of Sienna in Italy, they often constitute one-sixth of the fossil mass; they are also extensively distributed in the Crag of England* and of Belgium. So much in reference to what has existed; let us now throw a glance upon that which exists.

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We are in the present day acquainted with Foraminifers from every region of the sea, and we know that they exist in extent from the equator to the frozen portions of continents. If we judge of the important part they play by their numbers in certain quarters, it will be impossible to doubt that their remains form the greater part of the banks of sand which impede navigation, obstruct gulfs and straits, fill up ports, and form with corals those isles which are daily rising in warm regions from the bosom of the ocean.

Thus these minute shells, which, anterior to our epoch, have assisted in leveling basins of immense extent, and in forming mountains, are now still constantly changing the depth of coasts and modifying the bottom. This view of their agency in nature is doubtless sufficient to prove the importance which attaches to their study.

We will add, that the comparative study of the fossil Foraminifers of all beds has proved to us a fact important to geology, namely, that each bed has its characteristic species, which serve to distinguish it, let the circumstances be what they may; and as these minute shells are infinitely more common than those of Mollusks, the knowledge to be derived from them is so much the more certain, and becomes extremely interesting.

Another fact no less curious has been demonstrated to us by the study of living species from every region of the globe†. Many genera are peculiar to the hottest zones of continents, while others, on the contrary, are found only in temperate or cold regions. Hence the geographical distribution of living genera and species offers to us a means of comparison of the highest importance with a view to the determination of the temperature of the waters in which fossil species lived,

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† We are acquainted at present with nearly *fifteen hundred* living and fossil species of Foraminifers; and how many important facts may be derived from the study of these small bodies may be seen in three works which we are now publishing: 1. the Fauna of the Antilles, printed in *l'Histoire politique, physique, et naturelle de l'Ile de Cuba,* by M. de la Sagra; 2. that of the Canaries, published in *l'Histoire Naturelle* of those islands, by MM. Webb and Berthelot; 3. the Fauna of the southern extremity of America, forming a part of our *Voyage dans l'Amérique Méridionale.*

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We could have desired to establish some general facts of much greater extent, founded on new observations recently made by us on the class of the Foraminifers; but the present occasion not admitting such an extension, let us pass to the Foraminifers of the white chalk of the Paris basin.

The geological position of the white chalk of Paris is so well known that we have not thought it necessary to speak of it; yet, if we seek to determine its position relatively to the other cretaceous beds by means of the Foraminifers it contains, compared with living species, the *facies* of the genera and species proves to us, that the chalk of Maestricht, of Fauquemont (Belgium), of Tours, of Chavagne, and of Vendome, is above it; while, on the contrary, all the other beds are below it; thus in the chalk of Maestricht and the upper beds of the basins of the Loire, we recognize only genera still existing, or at least occurring in tertiary tracts, while the white chalk of the Paris basin already exhibits to us different genera, such as *Flabellina*, *Verneuilina*, and *Gaudryina*, and a great number of species quite distinct.

It would therefore be easy to establish, by means of the Foraminifers alone, the relative antiquity of the cretaceous beds; but we must previously make two geographical sections quite independent of each other, founded on the zoological forms; the first comprising the entire basin of the Seine, of the Loire, of Belgium, and of England, in which we find a striking analogy between the species found in all the beds, from the lowest to the highest, with a regular passage from one to the other; the second, comprising the West and South of France, in which the species of Foraminifers have not only no analogy with those of the other section, but in which, moreover, almost all the genera are different. If we seek an example of this fact, we shall find it on comparing the green sand of the environs of Mans with that of the mouth of the Charente. The first, which in fact contains species approximating to those of the white chalk of Paris, contains already several species analogous to those which have lived up to that bed; while the second, with perfectly distinct species, presents to us genera different from all that we know in the cretaceous beds of the North of France and of Belgium.

The Foraminifers are sufficient to establish the following descending order of superposition in the cretaceous beds:—

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The Foraminifers are sufficient to establish the following descending order of superposition in the cretaceous beds:—

Group of the North of France and of Belgium.	*Group of the West and South of France.*
Upper chalk of Maestricht and Fauquemont (Belgium).	
Coral chalk of Valognes and Nehou.	
Coral chalk of the basin of the Loire, at Vendome (Loir and Cher), at Chavagne (Maine and Loire), at Tours (Indre and Loire).	
White chalk of Ciply (Belgium).	
White chalk of Paris, of the departments of Yonne and Aube, and of England.	
	Nummulite chalk of Royan (Charente Inférieure), of Saint Martory (Haute Garonne), of Saint Gaudens, &c.
	Coral chalk of Saintes (Charente Inférieure).
Chalk marl of the Loire, with *Gryphæa columba.*	Ammonite chalk of Martrous, near Rochefort (with *Gryphæa columba*).
	Caprine chalk of the Isle of Aix, of the Corbières (Aude).
Green sand of Mans (Sarthe).	Green sand of Fouras, of the Isle of Aix, and Corbières.
Gault of the environs of Troyes (Aube).	
Neocomian tract of Aube.	

To establish zoologically what we have advanced, let us pass in review the succession of the genera, and endeavour to convey an idea of the modifications which have taken place in the Foraminifers of the cretaceous system, in the ascending order of the beds.

At the epoch of the Neocomian formation we have hitherto found only the genus *Textularia.*

The green sand presents, as we have said, two series of genera nearly distinct. That of the mouth of the Charente contains the genera *Dentalina*, *Cristellaria*, *Lituola*, *Alveolina*, *Chrysalidina*, and *Cuneolina*; that of Mans, the genera *Dentalina*, *Citharina*, *Frondicularia*, *Flabellina*, *Cristellaria*, *Bulimina*, and *Guttulina*. Hence we see, that, with the exception of two genera common to both localities, all the rest are different in each of them.

If we follow our examination of the succession of genera in the cretaceous groups of the South and the North, we shall find—

1. That in the South the same genera of the green sand are reproduced in the Caprine chalk. By degrees they prevail at length in the upper beds, and are reduced to the *Cristellaria* alone in the environs of Saintes; but near the mouth of the Gironde (at Royan) they are accompanied by the genera *Nummulina* and *Guttulina*, as well as on the whole line of the foot of the Pyrenees, at Saint Martory, at Saint Gaudens, extending into the department of Aude; thus pre-

Group of the North of France and of Belgium.	*Group of the West and South of France.*
Upper chalk of Maestricht and Fauquemont (Belgium).	
Coral chalk of Valognes and Nehou.	
Coral chalk of the basin of the Loire, at Vendome (Loir and Cher), at Chavagne (Maine and Loire), at Tours (Indre and Loire).	
White chalk of Ciply (Belgium).	
White chalk of Paris, of the departments of Yonne and Aube, and of England.	
	Nummulite chalk of Royan (Charente Inférieure), of Saint Martory (Haute Garonne), of Saint Gaudens, &c.
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Chalk marl of the Loire, with *Gryphæa columba.*	Ammonite chalk of Martrous, near Rochefort (with *Gryphæa columba*).
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Green sand of Mans (Sarthe).	Green sand of Fouras, of the Isle of Aix, and Corbières.
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Group of the North of France and of Belgium.	*Group of the West and South of France.*
Upper chalk of Maestricht and Fauquemont (Belgium). Coral chalk of Valognes and Nehou. Coral chalk of the basin of the Loire, at Vendome (Loir and Cher), at Chavagne (Maine and Loire), at Tours (Indre and Loire). White chalk of Ciply (Belgium). White chalk of Paris, of the departments of Yonne and Aube, and of England.	
	Nummulite chalk of Royan (Charente Inférieure), of Saint Martory (Haute Garonne), of Saint Gaudens, &c. Coral chalk of Saintes (Charente Inférieure).
Chalk marl of the Loire, with *Gryphæa columba.*	Ammonite chalk of Martrous, near Rochefort (with *Gryphæa columba*). Caprine chalk of the Isle of Aix, of the Corbières (Aude).
Green sand of Mans (Sarthe).	Green sand of Fouras, of the Isle of Aix, and Corbières.
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If we follow our examination of the succession of genera in the cretaceous groups of the South and the North, we shall find—

1. That in the South the same genera of the green sand are reproduced in the Caprine chalk. By degrees they prevail at length in the upper beds, and are reduced to the *Cristellaria* alone in the environs of Saintes; but near the mouth of the Gironde (at Royan) they are accompanied by the genera *Nummulina* and *Guttulina*, as well as on the whole line of the foot of the Pyrenees, at Saint Martory, at Saint Gaudens, extending into the department of Aude; thus pre-

senting a zone well characterized by the abundance of Nummulina, of which we have not found the analogue in the cretaceous beds of the North of France.

2. That in the North the succession is far from taking place in the same manner; and that the Foraminifers, in much greater numbers, present a larger suite in superposition, with facts not less curious. The genus *Citharina*, which constitutes the greatest portion of the species in the oolite formation, ceases with the green sand of Mans, being found no further in the cretaceous beds. In the chalk marl of the banks of the Loire we meet for the first time with the genus *Lituola* with the *Dentalina*; but all at once, in the white chalk, we observe a great number of species, among which, with all the genera and even some analogous species of the green sand of Mans, there appear for the first time on the globe the genera *Nodosaria*, *Marginulina*, *Valvulina*, *Rotalina*, *Rosalina*, *Truncatulina*, *Uvigerina*, *Verneuilina*, *Gaudryina*, *Globigerina*, *Pyrulina*, *Sagrina*, *Flabellina*, and *Frondicularia*. These genera contain a considerable number of species; but with the white chalk the genus *Flabellina* ceases, which had continued hitherto from the green sand, and the genera *Verneuilina* and *Gaudryina*, which first appear in the white chalk, also terminate with it; while in its interior the Frondicularia abound, as well as species whose cells form a pile on a single line.

The white chalk of Ciply, although contemporaneous with that of the Paris basin, since it also contains Flabellina, does not present the same species, and may perhaps be a little higher in the series, but we have not as yet sufficient data to enable us to affirm this fact.

In the beds which we consider higher in the series than the white chalk of Paris, namely, in the coral chalk of Tours, of Chavagne, and of Vendome, we meet for the first time with the genera *Polystomella*, *Polymorphina* and *Globulina*, yet accompanied with the same genera as those of the white chalk, with the exception of those whose discontinuance we have noticed; again, in the upper chalk of Maestricht and Fauquemont we have, with the three genera just mentioned, also the genera *Nonionina*, *Faujasina*, and *Heterostegina*. All are found living at present, or at least occurring in tertiary tracts; but we arrive at the last beds of the cretaceous group without having seen a single species of the *Miliola* of Lamarck (our order of Agathistègues), which, as we ascertained in 1825, only commences with the tertiary beds, and may be considered as the most certain sign of a change of formation.

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This rapid survey shows that in ascending from the lower

to the higher beds of the cretaceous group, the genera and species of Foraminifers progressively increase, and that the forms, at first very simple, analogous to those of oolitic tracts, afterwards more complicated and specially appropriate to the lower beds of the cretaceous system, have at last been replaced in the upper parts by forms still more varied, the whole recurring in tertiary tracts, and even in the living state; facts which it has appeared to us important to establish in the history of Palæontology.

M. A. d'Orbigny then proceeds to describe the species of Foraminifers found by him in the white chalk of the Paris basin. The following is a list of them, together with their localities:—

		Localities.
1.	Nodosaria limbata	Meudon: very rare.
2.	Dentalina aculeata	Common at Sens: more rare at Meudon and in England.
3.	———— communis	Meudon: rare. Its analogue is found fossil in the Subapennine tracts of Italy and Austria, and living in the Adriatic.
4.	———— gracilis	At Sens and in England.
5.	———— nodosa	Common at Sens, more rare at Meudon and St. Germain.
6.	———— Lorneiana	Only in the environs of Sens.
7.	———— sulcata	Very common at Sens, Meudon, and St. Germain, and in the chalk of England. Found also in the green sand of the environs of Mans (Sarthe).
8.	———— multicostata	Sens, St. Germain: rare. Also at Maestricht rarely.
9.	Marginulina trilobata	Common at Sens, very rare at Meudon, St. Germain, and in England: found only in the young state.
10.	———— compressa	Meudon: very rare. Occurs also in the green sand in the environs of Mans.
11.	———— elongata	Common near Sens, very rare at Meudon and St. Germain. Occurs also in the chalk of Ciply.
12.	———— gradata	Only near Sens.
13.	———— raricosta	Meudon: very rare.
14.	Frondicularia radiata	Meudon and St. Germain: very rare.
15.	———— elegans	Meudon and Sens: very rare.
16.	———— Verneuiliana	Common at Sens, on the banks of the Yonne; rare at St. Germain and Meudon.
17.	———— Archiaciana	Meudon and Sens: rare.
18.	———— ornata	Found only once at Meudon.
19.	———— tricarinata	Environs of Sens: seems to be rare.
20.	———— angulosa	Meudon: very rare.
21.	Flabellina rugosa	Sens and Meudon: common.
22.	———— Baudouiniana	Only at Sens.
23.	———— pulchra	Meudon: very rare.
24.	Cristellaria rotulata	Very common in the white chalk of Meudon, St. Germain, Sens, and in England. Occurs also in the green sand near Mans.
25.	———— navicula	Sens and Meudon: rare.
26.	———— triangularis	Sens: very rare.
27.	———— recta	Meudon and St. Germain: rather rare.

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	Localities.
28. Cristellaria Gaudryana	Only at St Germain : rare.
29. Lituola nautiloidea	Very common at Sens in the complete state, at St. Germain only young, and adult very rarely at Meudon. Occurs also in the chalk of England.
30. Rotalina Voltziana	Very common at Meudon, St. Germain, and in England.
31. ——— Micheliniana	Common at St. Germain, Meudon, and in England ; rare at Sens.
32. ——— umbilicata	Common at Meudon and St. Germain ; rare at Sens and in England ; common also in the tertiary tracts of Austria. Its analogue is found living at Rimini in the Adriatic, there being no difference between the fossil and living species.
33. ——— crassa	St. Germain, Meudon, and England : rather rare.
34. ——— Cordieriana	St. Germain, England, and upper chalk of Maestricht.
35. Globigerina cretacea	St. Germain and England.
36. ——— elevata	Common near Sens ; rare in England.
37. Truncatulina Beaumontiana	Meudon and England : rare.
38. Rosalina Lorneiana	Common at St. Germain and Meudon ; rare at Sens and in England.
39. ——— Clementiana	Rare at St. Germain, more common in England.
40. Valvulina gibbosa	St. Germain : rare.
41. Verneuilina tricarinata	St. Germain and Sens : rather rare.
42. Bulimina obtusa	Very common at Meudon ; rare at St. Germain and in England.
43. ——— obliqua	Very common at Meudon, St. Germain, Sens, and in England.
44. ——— variabilis	Very common at Sens ; rare at Meudon, St. Germain, and in England.
45. ——— brevis	Very common at Meudon, St. Germain, and Sens.
46. ——— Murchisoniana	St. Germain and England : rare.
47. Uvigerina tricarinata	Sens : very rare.
48. Pyrulina acuminata	Very rare at Sens and St. Germain ; very common at Meudon.
49. Gaudryina rugosa	Meudon, St. Germain, and Sens : rather common.
50. ——— pupoides	Rather common at Meudon, Sens, St. Germain, and in England.
51. Textularia trochus	Only at Meudon.
52. ——— turris	Sens, Meudon, St. Germain, and England, without being common.
53. ——— Baudouiniana	St. Germain and Meudon : rare.
54. Sagrina rugosa	St. Germain and Meudon.

From the preceding list it appears, that of the fifty-four species found in the white chalk of the Paris basin, *thirty-eight* occur at Meudon, *thirty-three* at Saint Germain, and *twenty-eight* at Sens: of these numbers, *nine* are peculiar to Meudon, *two* to Saint Germain, and *six* to Sens, while all the others are simultaneously common to two or three localities, thus proving the perfect identity of the beds. It will be seen also, that of these fifty-four species, *twenty-two* are common to the white chalk of England also.

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Of the fifty-four species, *seven* occur also in lower or higher beds: thus in the green sand of Mans are found three species, *Dentalina sulcata*, *Marginulina compressa*, and *Cristellaria rotulata*; in the coral chalk of Tours, which is higher in position than the white chalk, two species, *Bulimina obtusa* and *Textularia turris*; and in the chalk of Maestricht, being the highest in position, two species, *Dentalina multicostata* and *Rotalina Cordieriana*. We also find two species, the analogues of which occur both fossil in the tertiary tracts of Austria and Italy, and in the living state in the Adriatic, namely, *Dentalina communis* and *Rotalina umbilicata*. With these exceptions there still remain *forty-seven* species peculiar to the white chalk, showing clearly that it forms a bed distinct from all the rest of the cretaceous system, belonging to a small local fauna well-defined.

On comparing the above genera given by M. d'Orbigny with those named by Dr. Ehrenberg in his tabular view of the Bryozoa, inserted in the early part of this paper, it will be seen that Nodosaria, Dentalina, Marginulina, Frondicularia are included in the family of the Nodosarina of the latter author; Cristellaria, Rotalina, Truncatulina, included in his family of the Rotalina; Globigerina, Rosalina, Valvulina, Bulimina, Uvigerina, Pyrulina, in his family of the Uvellina; and Textularia in his family of the Textularina. The *Lituola nautiloidea* of Lamarck and d'Orbigny is the *Coscinospira nautiloides* of Ehrenberg, included in the Fabularina family of the latter.

If we now, observes M. d'Orbigny, compare the fauna of the Foraminifers of the white chalk with those of different seas, with a view of determining the analogy of composition, and of obtaining data respecting the temperature of that basin at the time when these species lived, we shall find this analogy more striking in the Adriatic Sea than anywhere else. There only, the same as in the chalk, are found in abundance Nodosaria, Dentalina, Marginulina, Frondicularia; there only occur a considerable number of species of Bulimina. This sea alone in the present day contains living Frondicularia; of Frondicularia so varied in the white chalk; and, to complete the approximation, it exhibits to us the only two living species, the analogues of which are found in the fossil state in the white chalk, namely, *Dentalina communis* and *Rotalina umbilicata*. This analogy of zoological forms would lead us to believe, 1st, that the basin in which is deposited the white chalk of Paris was subject to a warm temperature; 2nd, that it was circumscribed, protected from waves and from every violent current proceeding from a distance, since the bodies

Of the fifty-four species, *seven* occur also in lower or higher beds: thus in the green sand of Mans are found three species, *Dentalina sulcata*, *Marginulina compressa*, and *Cristellaria rotulata*; in the coral chalk of Tours, which is higher in position than the white chalk, two species, *Bulimina obtusa* and *Textularia turris*; and in the chalk of Maestricht, being the highest in position, two species, *Dentalina multicostata* and *Rotalina Cordieriana*. We also find two species, the analogues of which occur both fossil in the tertiary tracts of Austria and Italy, and in the living state in the Adriatic, namely, *Dentalina communis* and *Rotalina umbilicata*. With these exceptions there still remain *forty-seven* species peculiar to the white chalk, showing clearly that it forms a bed distinct from all the rest of the cretaceous system, belonging to a small local fauna well-defined.

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are deposited there without having experienced the slightest wearing previous to their becoming fossil; 3rd and lastly, that it extended to the whole of the white chalk of England.

Concluding Remarks.

The preceding extracts from the labours of Dr. Ehrenberg and M. A. d'Orbigny show that microscopic Polythalamia are found in all calcareous formations from the lias upward; but in England they have been lately discovered in still deeper strata. Mr. Tennant was, I understand, the first to announce their discovery in 1839 in the mountain limestone of England. In 1840 they were also met with in the Kendal limestone, from which Mr. Lonsdale has prepared thin slices mounted on glass, which appear transparent under a strong light, exhibiting the crowded state of the microscopic Polythalamia in great perfection. Mr. Bowerbank also has been led to turn his attention to this subject by examining the siliceous bodies of the chalk, green sand, and oolites*.

I had written thus far, when an interesting article by the Rev. Dr. Buckland, in reference to the researches of Dr. Ehrenberg up to 1839, met my eye, entitled, "On the agency of Animalcules in the formation of Limestone†," which notices in particular the researches of MM. Tennant and Darker on this subject in the Derbyshire limestone and the Stonesfield slate, as well as the labours of Mr. Bowerbank, referred to above, and conveying judicious reflections. Dr. Buckland justly remarks, that in the application of the microscope from the living to the fossil Infusoria and Foraminifers we are commencing a new and important era in Palæontology. A very interesting branch of the inquiry will be to ascertain whether these microscopic bodies retain throughout a distinctive character in the several formations into whose composition they enter. In the unbounded field of nature presented to the consideration of the Microscopical Society of London lately established, no subject appears more worthy of their attention than an examination of the microscopic organic constituents of all the older limestone formations of the British Isles, as well as of other countries; and it is much to be desired that this attention may not be wanting, although the concurrence of many labourers may be required to reap a harvest of great promise, yet of indefinite extent.

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